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Assessment of right ventricular outflow tract fractional shortening as a measure of right ventricular function in chronic heart failure patients

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Abstract:

Background: assessment of RV function is a major component of the management and prognostication of heart failure (HF) patients. Its complexity makes this task difficult and therefore not appropriately considered. Right ventricular outflow tract fraction (RVOT FS) can serve that purpose if done. The functional capacity of a HF patient must always be assessed and decision made on that basis.

Aim of the study*:* this study aimed to investigate the applicability of RVOT FS in assessment of RV function and also its relation to functional capacity.

Patients and methods: seventy-one (71) patients with heart failure with reduce ejection fraction (HFrEF) were studied prospectively and nineteen (19) control healthy individuals (normal ECG, normal left and right ventricular function and no cardiac risk factors). A 2D guided M-mode was taken in the parasternal short axis view to determine RVOT FS and a six-minute walk test (6MWT) was done to determine their functional capacity.

Results*:* there was a reduced RVOT FS reduced in the HFrEF group (p value =0.005), 6MWT D was reduced in the HFrEF group (p value <0.001), there was a positive correlation of RVOT FS with RVFAC (r=0.839, p value<0.001) TAPSE (r=0.830, p value<0.001), S'(r=0.830, p value<0.001) 6MWT D (r=0.953, p value<0.001) and a negative correlation with RIMP(r=-0.867, p value<0.001), RV FLS(r=-0.878, p value<0.001), SPAP(r=-0.633, p value<0.001). 6MWTD with RVFAC (r=0.851, p value<0.001) TAPSE (r=0.825, p value<0.001), S' (r=0.837, p value<0.001), RVOT FS (r=0.953, p value<0.001) and a negative correlation with RIMP (r=-0.827, p value<0.001), RV FLS (r=-0.902, p value<0.001), SPAP (r=-0.621, p value<0.001). RVOT FS between HF subgroups significant (p value<0.001).

Conclusion*:* RVOT FS is a simple and reliable parameter that can be used in assessment of RV function and has very positive correlation with functional capacity assessed by 6MWT.

Keywords: right ventricular outflow tract, chronic heart failure, right ventricular function

Introduction:

Chronic heart failure has recently been defined as Heart Failure (HF) diagnosed ≥3month duration[(1)]. Recently heart failure has been classified into heart failure with reduce ejection fraction (HFrEF), with mid-range (HFmEF) and preserved ejection fraction (HFpEP)[(2)]. It has long been established that clinical presentation and prognosis of heart failure patients is highly dependent on the RV function[(3–5)] The complexity of RV geometry has for long hindered the adequate assessment of RV function[(6–9)]. Right ventricular outflow tract fractional shortening is a new parameter that can be used to ease this distress[(10,11)].Functional capacity is a major determinant and a prognostic factor in the life of a HF patient and this ought to be determined [(12–14)].

Aim of the work:

The aim of this study was to investigate the applicability of RV outflow tract fractional shortening (RVOT-FS) in the evaluation of RV function in patients with chronic HFrEF. Secondly to investigate the correlation between RVOT-FS and exercise capacity in patients with chronic HFrEF.

Patients and methods:

Study design*:*

The study was performed in Al Hussain University Teaching Hospital of Al Azhar University, Cairo-Egypt for 1year period from November 2017 to October 2018. This study was conducted prospectively on ninety individuals categorized into two groups. These groups were control group (19 individuals) healthy individuals (Normal ECG, normal left and right ventricular function[(15)] and no cardiac

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risk factors) and HFrEF group (71 patients). Inclusion criteria was age > 18year, chronic heart failure diagnosed ≥3month, aetiology caused by coronary artery disease, or hypertensive heart disease, or idiopathic cardiomyopathy. Heart failure was defined as having HFrEF if left ventricular ejection fraction (LVEF) was <40%[(2)]. Exclusion criteria was patients with acute heart failure or heart failure < 3months, all patients with significant arrhythmia, previous history of right heart failure or diagnosis of: group 1 PH (e.g., pulmonary arterial hypertension), group 3 PH (PH associated with lung respiratory diseases and/or hypoxia), group 4 PH (PH due to chronic thrombotic and/or embolic disease) and group 5 PH (PH associated with a miscellaneous of rare diseases) any orthopedic function or cognitive function impairment, poor echocardiographic window, age less than 18 year, more than moderate MR, and limiting neurological disease.

Clinical history and examination

Informed consent was taken from all patients for the study participation; careful history was taken from all patients for assessment of heart failure with emphasis on exercise tolerance of the patient, previous diagnostic tests done, mainly ECGs, echocardiography, nuclear scans, cardiac CT, CMR and coronary angiography. Focused clinical examination was done and a resting 12 lead ECG.

The HF patients were further classified into subgroup according to their exercise tolerance to New York heart association (NYHA) I-IV[(16)].

Echocardiography:

Standard transthoracic two-dimensional and Doppler echocardiographic examination was carried out with Philips iE33 X Matrix" ultrasound machine using "S5-1" matrix array transducer (Philips Medical Systems, Andover, USA) equipped with STE technology, using a multi frequency (1- 5 MHz). ECG-gated examination was done to optimal image acquisition and later analysis.

Left ventricular assessment*:* left ventricular end diastolic dimension (LVEDD) was determined by M-mode and left ventricular ejection fraction (LVEF) was determined by Simpson's biplane of disc method according to the American Society of Echocardiography(ASE)[(15)].

Right ventricular assessment*:* RV focused view was obtained from the apical four chamber view and the following measurements were obtained according the ASE[(7,15)]. I) TAPSE: Was measured by M-mode with the cursor optimally aligned along the direction of the tricuspid lateral annulus and the systolic excursion distance measured with < 17mm considered abnormal. II) RVFAC: this measurement was obtained by manually tracing the RV endocardial boarder in the systole and diastole of same frame, a value < 35% was considered abnormal. III) Right ventricular index myocardial performance (RIMP) and DTI-Derived Tricuspid Lateral Annular Systolic Velocity (S) were measured by aligning color tissue Doppler cursor to the lateral TV annulus and recording the maximum systolic velocity(S) and from one heartbeat RIMP = (IVRT + IVCT)/ET = (TCO-ET)/ET. IV). Right ventricular free wall longitudinal strain (RV FLS) manual tracing of the endocardial border of the RV over single frame the endocardial borders where automatically be tracked throughout the cardiac cycles. V). Systolic pulmonary artery pressure (SPAP) was estimated by measuring peak systolic tricuspid gradient and adding estimated RAP by measuring the IVC.[(15)]

Right ventricular outflow tract fractional shortening (RVOT FS), a 2D zoomed guided M-mode is obtained in parasternal short axis view in the distal RVOT, end diastole and end systole using endocardial leading-edge to obtain the as RVOT FS % = (RVOT ED - RVOT ES)x100/(RVOT ED) [(10)].

Six-minute walk test distance (6MWT D), patients were asked to walk for 6 minute at their own pace in a corridor of about 10m to and fro, the distance covered was then calculated after wards.[(17)]

Statistical analysis:

Obtained data were recorded in Microsoft excel work sheet and analyzed using SPSS 20.0, categorical data was presented as frequencies and percentage, while continuous data were presented in mean±SD. Chi square was used to analyze categorical data, independent T-test was used to compare continuous data in the two groups, analysis of variance(ANOVA) with Turkey significance was used to compare the NYHA groups and a Pearson or Spearman

correlation was calculated to show the relation between variables.

Results:

Demographic and risk factors data showed no statistically significant difference between the two groups, Age 49.58±8.83 in control vs 50.87±6.94 in HF with P value =0.498, Gender 10 out of 19 were male in control and 39 out of 71 were male with a p value =0.858, Smoking, Hypertension and Diabetes mellitus had P value =0.391, P value =0.102 and P value =0.083 respectively.

Table 1: demographic and risk factors between the two groups

Group	Group 1(control)	Group 2(HF)	P value
Age	49.58±8.83	50.87±6.94	0.498
Gender	10 M vs 9 F	39 M vs 32 F	0.858
Smoking	Yes 5 vs No 14	Yes 25 vs No 46	0.391
hypertension	No (19)	Yes 9 vs No 62	0.102
Diabetes mellitus	No (19)	Yes 10 vs No 61	0.083

There was a statistically significant difference in the echocardiographic findings, included RVOT FS and 6MWT D between the two groups with a significant p value as shown in table 2.

Table 2: comparison of echocardiographic parameters between the control and heart failure group and their 6MWT D

PaTEInts	**Control (19)**	**HF (71)**	**P value**
LVEF %	64.32±5.67	25.44±6.86	<0.001
LVEDD (mm)	48.16±4.94	69.96±5.98	<0.001
S' (mm/s)	15.32±2.43	11.25±4.32	<0.001
RIMP	0.41±0.045	0.52±0.10	<0.001
RV FLS	-25.16±2.79	-16.07±7.79	<0.001
eSPAP (mmHg)	10.63±6.64	48.80±14.58	<0.001
6MWT (m)	582.79±61.61	296.59±176.37	<0.001
RVOT FS (%)	48.39±7.11	37.54±16.11	0.005
TAPSE (mm)	24.95±3.86	17.32±6.10	<0.001
RVFAC %	43.74±4.55	33.85±11.2	<0.001

There was a statistically significant correlation between the RVOT FS and all other RV systolic parameters and also 6MWT D as shown in table 3.

Table 3- Pearson correlation between the RVOT FS and other RV systolic parameters and functional capacity

ROVT FS	**Pearson Correlation (r)**	**P Value**
TAPSE	0.830	<0.001
RVFAC	0.839	<0.001
S'	0.830	<0.001
RIMP (TIE Index)	-0.867	<0.001
RV FLS	-0.878	<0.001
SPAP	-0.633	<0.001
6MWT D	0.953	<0.001

There was a significant correlation between functional capacity of the patients with their RV function including the RVOT FS and there was no correlation with the LVEF and LVEDD as shown in table 4.

Table 4: Pearson correlation between the functional capacity, RV systolic parameters and left ventricular parameters

6MWT D	**Pearson Correlation (r)**	**P Value**
LVEF	0.086	0.477
LVEDD	-0.010	0.996
TAPSE	0.825	<0.001
RVFAC	0.851	<0.001
S'	0.837	<0.001
RIMP (TIE Index)	-0.827	<0.001
RV FLS	-0.902	<0.001
SPAP	-0.621	<0.001
RVOT FS	0.953	<0.001

There was no statistically significant difference between NYHA class in respect of their LVEF and LVEDD, but there was a highly statistically significant difference between these classes regarding their RV systolic parameters including RVOT FS and 6MWT D as shown in table 5.

Table 5: comparison between HF subgroups regarding echocardiographic findings

Heart failure	NYHA I N=27	NYHA II N=12	NYHA III N=14	NYHA IV N=18	P Value
LVEF	25.44±6.21	25.17±5.89	26.79±6.47	24.56±8.81	0.842
LVEDD	70.11±6.0	70.75±5.94	68.71±4.70	70.17±7.12	0.842
TAPSE	21.78±3.96	20.67±5.40	14.29±3.99	10.78±2.39	<0.001
RVFAC	42.44±5.96	40.50±10.72	27.79±6.35	21.22±3.72	<0.001
S'	14.67±3.33	13.50±2.844	8.64±1.906	6.67±1.414	<0.001
RIMP	0.45±0.050	0.48±0.07	0.56±0.09	0.63±0.04	<0.001
RV FLS	-22.22±2.17	-20.92±3.00	-13.14±6.16	-5.89±3.740	<0.001
SPAP	41.56±8.74	38.75±9.91	52.07±15.03	63.83±10.93	<0.001
ROVT FS	52.96±3.80	45.03±5.37	28.26±8.69	16.61±4.30	<0.001

Discussion:

RV has been a neglected entity for quite long by the scientific and cardiology community[6,7], this has recently changed due to emerging evidence of its role in major cardiopulmonary diseases[18] and more importantly a prognostic factor in HF mortality[3,4],[19]. Functional capacity in HF patients and response to CRT has been closely related to RV function not LVEF[20,21].Determination of RV function has been a nightmare to the cardiologist due to the 3D complex structure of RV[7], making the need for CMR or Radionuclide studies as gold standards in assessment of RV function[8,9]. RVOT FS has been suggested to be a good marker of RV function and also prognostic value[10,11,22].We studied a group of HF patients in comparison to control and found a significantly reduced RVOT FS along with other parameters in compared to the control group, which is similar to the findings of some author of **Lindquist *et al.* [10], Deveci *et al.*[23] and Allam *et al.*[24].** We also showed a reduction in functional capacity between the groups similar to the reports of **Lipkin *et al.*[25],** who also compared HF patients with the control. We found a very significant correlation between RVOT FS and all other RV parameters taken in this study even more correlate with RIMP, RV FLS and RVFAC which were less angle dependent. These findings are similar to those of **Lindquist *et al.* [10], Deveci *et al.*[23] and Allam *et al.*[24]** except none of the mentioned studies took all the validated RV parameters and none compared to RVOT FS with RV FLS.

We also found a very significant correlation between RVOT FS and functional capacity of our study patients by using 6MWT which is so far the first study to make this observation to the best of Our knowledge. This is in conformity the known fact that RV function is a major determinant of HF patient functional capacity. There was also no any correlation between the RVOT FS and LVEF in our study, this similar to the findings of **Allam *et al.*[24]** and contrary to **Yamaguchi *et al.*[11] and Deveci *et al.*[23], Asmer *et al.*[26]**, this could be explained by different population and geographic group studied by the two studies mentioned.

We studied the functional capacity of the HF patients in relation their LV and RV parameters and found no any correlation between the functional capacity and LVEF and LVEDD, which is similar to the findings of **Deveci *et al.*[23]** though they used NYHA functional classification as their parameter for functional capacity. It is similar to results of **Naibé *et al.*[27]** findings who conducted 6MWT in patients with HF. This is in disagreement to the findings of **Wegrzynowska-Teodorczyk *et al.*[28] ,**who demonstrated a statistically significant relation, this could possibly be due to difference in race and geographic population of study. There was a very significant correlation between 6MWT D and all the studied RV parameters and this in total agreement with the findings of some authors as **Di Salvo *et al.*[29], Yamaguchi *et al.*[11], Deveci *et al.*[23], Ghio *et al.*[3], Meyer *et al.*[30], Ghio *et al.*[19,31], Guazzi *et al.*[19], Kjaergaard *et al.*[32], Wegrzynowska-Teodorczyk *et al.*[28].**

And finally, we demonstrated a significant statistical relation between NYHA class and RV systolic parameters (TAPSE, RVFAC, eSPAP, RIMP (Tie index), S', RV FLS and RVOT FS). This is in agreement with findings of **Bulent Deveci *et al*[23], Yamaguchi *et al.*[11], Srinivasan *et al.*[33], Meyer *et al.*[30], Passantino *et al.*[34].** Though NYHA seemed not to have any relation with LVEF or LVEDD of our patients which is contrary to the findings of **Wegrzynowska-Teodorczyk *et al.*[28].**

Limitations of this study:

This study was limited by it being a single centre study, not use of CMR which is the gold standard in the assessment of RV function but this is due to constraint in the available resources. Cardiopulmonary exercise was not used as the gold standard in assessing functional capacity but 6MWT has received several validations for that purpose. The study is also limited by a relatively small sample size.

Conclusion:

RVOT FS is a simple non-invasive echocardiographic parameter that can be used to assess RV systolic function with a high degree of precision and can be used solely or in addition to other parameters. It may also give some prognostic information on the patient.

Conflict of interest*:* none

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